ON VAN WYK'S VLEY RESERVOIR.

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Before proceeding with the main subject of this paper, it may not be out of place to make a few remarks on Boer dams in general, showing that more care should be taken in the selection of their sites, and in their mode of construction.

Many of these sites are far from being good ones, some having such small catchment areas that they never half fill, and their constructors have the mortification of seeing a huge bank, with little water, besides being put to much unnecessary expenditure; others again are constructed on a porous stratum through which the water percolates away rapidly, rendering the dam almost useless for irrigation purposes and only giving water for stock for a comparatively short time. These faults can be avoided by making a proper survey with levels, and by sinking pits along the proposed line of bank, to ascertain the nature of the strata forming the foundation.

A common fault in many of these dams, is that the inside or water slope is made too steep, causing the pitching to get loose and fall out in many places, thus giving free access to the wash of the water, and to the ravages of crabs. This if not noticed and repaired at once, may often cause the entire destruction of the bank, and the loss of a whole season's water and crops.

More care should be taken to incorporate the bank with the ground on which it is to be made. This is done by removing all loose stones, sand and bushes, and picking the ground to a depth of eight inches or so, before beginning the first layer of the bank.

The general method adopted amongst the farmers in the construction of their dams is to convey the ground to the site of the bank, in carts or scrapers, allowing it to assume its natural slope, or angle of repose. This for most kinds of ground is quite insufficient, when exposed to the action of rain or standing water. A farmer once called on me and said he had just entered into a contract for the construction of a reservoir bank on his property for a certain sum, and now wished to know how much earthwork would be required to finish the work, insisting, in spite of my remonstrances, on only giving such slopes as the material would stand at when first tipped. The slopes were not to be pitched, owing to the scarcity of stones. It will scarcely be a matter of surprise, if this dam, so constructed, should be washed away by the first heavy rain.

Another fault in many of these dams is that too little attention is paid to their overflows, and this is a very serious one, for the existence of the bank depends almost always on a proper provision being made to carry off the surplus water after the dam is full. If this point is neglected the water will rise till it reaches the crest of the dam, when it then only becomes a question of time for it to share the fate of many others whose safety valves have been omitted or made too small.

It is scarcely a matter of wonder to hear of so many dams having given way after a heavy rainfall, when they are made in this haphazard style by men who have little knowledge how to construct a bank able to withstand the denudation caused by alternate filling and emptying as well as by the insidious percolation of standing water.

Outlets should, where practicable, be placed some distance from the bank, a natural 'nek' being best, but where such is not to be found, the overflow may be formed by making a cutting, or by leaving a sufficient opening at the end of the bank. In the event of the latter plan being adopted, the bottom, and side next the embankment, should be protected from scour by substantial stone pitching. A training wall or bank must also be made to lead the water clear away from the outside slope, and protected with stones or bushes where necessary.

Front slopes should always be pitched, if there are suitable stones to be procured in the neighbourhood, to prevent damage from burrowing of crabs and trampling of cattle.

From the foregoing remarks it is not to be understood that all the dams in the country are badly made, far from it, for there are many excellent ones, which have stood firm for years, proving a source of wealth to their owners, and showing them that substantial work pays the extra outlay in the long run. But althou h some grave errors have been pointed out in the general construction of dams, the farmers are not altogether to be blamed, for they have to contend with many difficulties and troubles which most people in the large towns know little or nothing of. What they have chiefly to struggle against are the terrible droughts which are so frequent in the back country, and which sometimes last for years, reducing well-to-do farmers to a state of bankruptcy. Often and often are they obliged to shut up their houses, collect what stock is left to them, and trek with their wives and families to distant parts of the country in search of veldt and water, not knowing when they again can return to their homes.

How then can it be expected that people, living in this hand-to-mouth manner, are able to pay for expensive surveys and construct proper and substantial works? It is entirely out of their power, and the most they can do is to construct, with what labour they have about the farm, a dam to hold as much water as possible, adding to it as time and opportunity permit. Often a heavy storm destroys all their labour, before the work is properly finished.

An Irrigation Act was passed a few years ago, authorising the loan of money, on easy terms, to enable farmers to construct dams, and other works, for irrigation purposes, and many took advantage of it, but a great deal has yet to be done to give effectual assistance to the poorer class of farmers.

The Dutch farmer, as a rule, adheres tenaciously to the methods used by his forefathers, in dam making and farming, but many are now appreciating the use of such scientific appliances as siphons, turbines, and pulsometer or other pumps for irrigation.

When he sees lands which are regularly irrigated, thriving and producing all kinds of crops and grain, whilst his own are dried and parched with drought, he naturally wishes to possess the like, and I have no doubt that, in course of time, large tracts of fine land which now only afford a precarious support to a few sheep and goats will be made to produce an abundant supply of grain and other produce, the most of which, at the present time, has to be imported at a great cost.

Those who have travelled much in the Karroo cannot have failed to observe that wherever a farmer has been able to irrigate, the luxuriant vegetation appears to the eye, wearied by miles and miles of dry and stunted bushes and with nothing to vary the monotonous appearance of the country, to be a veritable oasis in the desert. There is no reason why these patches of cultivation should not be more numerous and extensive than they are at present, for on most farms there are sites more or less favourable for storing the rain which falls so seldom, and which should in consequence be preserved as much as possible, to meet the demands in time of drought.

Many of these sites are on Government lands, and the one at Van Wyk's Vley is one of the most extensive and favourable yet brought to the notice of the public. A short description will now be given of the manner in which the works at that place were carried out. The designs were prepared by Mr. John G. Gamble, the Hydraulic Engineer to the Colony. The contract for the work was signed on the 28th October, 1882, and the first ground was broken on the 1st December following, the author having been appointed resident engineer.

Before the contract was given out for tender, trial pits were sunk along the centre line of the bank in order to find, if possible, an impermeable stratum on which to found the puddle core. These were put down by the foreman (R. Taylor) who came out from England to undertake borings. He found on the one side of the kolk or river a stratum of hard rock, varying from 8 feet to 17 feet below the surface of the ground. Close to the east side of the river, no rock could be found, and it was supposed to have been cut off in or near to the other side, this was afterwards, as the work proceeded, found to be correct. Instead of rock, a succession of shales was found, overlaid on the koppies, which formed the abutments of the bank, by beds of a very hard rock, which are much split up but cemented together by deposits of lime. A bore hole was put down on the east side by Taylor to a depth of 50 feet but he did not get through the shale. These shales for a depth of 10 or 12 feet were of a very friable and porous nature, and it was found necessary to excavate to a considerable depth to get a good foundation.

The contractors (Messrs. Gillet & Perez) then began the work by clearing the ground of all stones, sand and bushes, and by loosening it with picks and ploughs to a depth of 8 inches. On this prepared foundation the embankment was raised. Simultaneously with the starting of the bank, a trench was excavated, extending the entire length of the bank, and down to the rock where rock could be found. This trench was 8 feet wide at the bottom, the sides having a batter to meet the puddle core of the bank, at the natural surface of the ground. It was then filled in with puddled clay, made as will afterwards be described. The puddle core or wall, placed in the centre of the bank was carried up to within 3 feet of the top, where it reached its minimum width of 4 feet, its sides having a batter of 1 in 5.

Great difference of opinion exists amongst engineers as to the proper position of puddle in earthen dams. Some advocate the placing of a layer on the face of the inner slope, immediately below the pitching. This method can certainly not do much harm, but it is doubtful if it does much good, at all events for banks of any great height, for in this hot climate, when the water in the reservoir is low the puddle is liable to crack and this materially affects its usefulness.

Another plan is to construct a puddle wall in the centre of the bank, continuing it down till the rock or an impermeable strata is reached. This was the method adopted here. The use of this puddle wall is to prevent as far as possible a leakage of water through the bank, which might prove dangerous to its safety, and which is generally caused by bad workmanship, use of permeable material or the burrowing of crabs and mice.

Most people know what the meaning of puddle is, but for the benefit of those who do not, the following description may be useful. The material used is clay, freed from roots, stones and dirt. When made by hand, it is mixed with water, cut up and worked with spades, well tramped and kneaded until it is of the consistency of putty. It was made in this manner for Van Wyk's Vley reservoir. If the clay is pure, as much sand may be mixed with it as is consistent with its holding water, for if there be too little sand it is liable to crack in dry weather. This would more particularly apply to puddle laid on the slope than to that in the centre of a bank. If too much sand is used the puddle will become porous and therefore useless for the purpose for which it is required.

After the puddle was made, it was brought on to the bank in carts drawn by mules, which were found to be much better than bullocks or donkeys for this part of the work, and then spread in horizontal layers about 9 inches thick, well beaten down to the preceding layer, which was first thoroughly wetted, so that the layers would amalgamate together.

Each layer as far as possible was carried the entire length of the bank at once, but where this could not be done steps, of a thickness of one layer, were left so that a proper junction could easily be made.

The forming of the bank and the puddle core were carried on simultaneously in the following manner. When a layer of puddle was finished, it was allowed to dry till it was sufficiently stiff to bear the pressure of the earth placed alongside it. This was brought on in mule carts, while the bullock and donkey carts were worked towards the outside of the bank. This way of working was necessary because bullocks and donkeys cannot be guided so well as mules or horses, and when once on to the puddle, they sank for several feet, and it was then a matter of great difficulty and loss of time to extricate them.

The earthwork of the embankment was made in layers of about 1 foot thick and well beaten down with heavy rammers before the next was laid on it. The best material was selected and placed to form the water side of the bank, extending back to the puddle core. No stones or shale were allowed on this part of the work, but could be placed behind the core of the bank, due care being taken that there was sufficient fine material to make the mass solid.

The embankment was formed in concave layers, that is to say, the bank was kept from 2 to 3 feet higher on the outside, sloping downwards to the puddle core. This method makes the bank more solid and tends to prevent slips, and should always be adopted, the extra trouble being more than compensated for by having a stronger bank, with the same material.

The contractor, not being a man to lose time or waste opportunities, took advantage of moon-light nights to bring on the earthwork. This was entirely confined to men who owned one or two spans of bullocks, one span working during the day, and the other at night. He paid for the work done at so much per load, brought on to the bank, a certain number of loads being fixed as a minimum, for men had to be employed in spreading and ramming the ground. In order to keep tally of the number of loads, each driver received a ticket from the man in charge when he tipped his load, and when the number of tickets reached ten, they were exchanged for another representing ten, and in the same way when these reached ten, they were given up for one worth 100. These tickets were presented at the contractor's office at the end of the week and paid for according to the rate per load. This system worked well and a large amount of work was thus done. When the bank had been raised to a convenient height levelled pegs were put in, and the front and back slopes trimmed to their respective batters of 3 to 1 and 2 to 1. The front slope was then covered to a thickness of 18 inches, with a layer of stones and small boulders, on which was placed the pitching of stones 12 inches thick.

To guide the men in laying the pitching properly, pegs were placed at intervals of about 30 feet along the bank, and about 20 feet apart down the slope, on which stout cords were stretched, thus giving the proper level and slope. When the pitching was finished a layer of small stones or gravel was spread over it and raked about to fill in the interstices between the stones.

As all made-banks are liable to settle down more or less, the top as finished was kept higher than the normal level, by one half-inch for every foot of vertical height.

A coating of 3 inches of gravel was spread over the top of the bank to protect it from rain, and the trampling of cattle and sheep; and along the edge of the inside slope a dry stone wall 2 feet wide by 2 feet high was built as a protection from spray, &c.

The water is led from the reservoir to the main furrow, by means of two iron pipes, one of 20 inches in diameter and the other 12 inches. These pipes pass through a culvert made of concrete 4 feet wide by 6 feet high, which is built in the solid ground in the kopje which forms the east abutment of the embankment. At the reservoir end of the culvert is built a stone tower, in cement mortar, 33 feet high, with an external diameter at the base of 13 feet, and at the top 10 feet; the internal diameter being 5 feet. This tower is for the purpose of working the different valves, of which there are five in all, each of the two pipes being provided with two, a shuttle valve on the outside, and an ordinary one in the inside of the tower.

The fifth valve is a 6-inch one to be used for any water which may collect in the tower. Access is obtained to the top and inside of the tower, for working the valves, and for making repairs, by means of iron steps built into the masonry.

The top of the tower is covered with cast-iron plates, resting on the walls and on the channel irons, which support the pillars through which the valve rods pass.

The 20-inch pipe passes through the base of the tower, its centre being nearly 26 feet below the highest water level. It is then laid on the floor of the culvert, extending as far as the plug wall, or as far as the puddle core of the embankment.

The 12-inch pipe draws water from the reservoir at a point 13½ feet below the highest water level, passes down through the tower into the culvert, where it rests on brackets supported on short iron columns, at a height of 3½ feet above the floor.

At intervals of 9 feet along the top of the culvert, masonry rings, set in cement mortar, 2 feet wide and 1 foot thick, were built to arrest as much as possible any percolation of water, and so that the earthwork and puddle of the bank should join firmly with the masonry. The filling in of the space between the top of the arch and the surface of the ground was carefully done. A layer of ground was first put in and thoroughly soaked with water, well trampled and rammed till all the interstices between the culvert and the excavation above the springing of the arch were filled in. After the pipes and valves were properly fixed, the portion of the culvert from the tower for a distance of 75 feet was built in solid, the material used being principally concrete with a little masonry. This plug was made longer than is usual, on account of the shaly nature of the ground below the culvert. The depth of this shale, as I before mentioned is unknown, a 50-feet bore having failed to pierce it. It is not unlikely that the water from the reservoir will soak through this shale and issue out at some point or points beyond the bank.

Advantage has been taken of a nek some distance from the bank to construct the overflow. The ground was excavated and levelled for a width of 150 feet, which is calculated to be amply sufficient to carry off the surplus water.

When the water in the dam is on a level with the bottom of the 20-inch pipe, that is, is empty, the area of what remains in the kolk is 34 acres. This can only be used for watering stock. The extent of land covered by water when the dam is 4 feet deep at the tower, is 500 acres, and at present (March 1886), with a depth at tower of 6½ feet, it is at least 800 acres.*

Beacons have been erected at suitable points outside the dam so that its area can be easily and expeditiously measured at different levels. This will subsequently be of great value, as a close approximation can be made as to the amount of water available for irrigation and other purposes.

Careful and regular measurements have been taken of the depths of the water in the dam to find out, as far as possible, the rate of evaporation and soakage.

No water at all was taken from the dam in 1884, so the amount as shown in the annexed table represents exactly what was lost by evaporation and soakage during that period.

Irrigation was first commenced in July 1885, and has been continued up to the present time.

The amount of land under cultivation is about 25 acres, but the water used for this patch bears a very small proportion to that lost by evaporation. In a whole day's leading, no appreciable difference in level of reservoir could be detected, the loss during the year 1885 may be considered as almost entirely from evaporation and percolation. The observations of the two years can thus be compared, from which

* No chance to measure yet.

will be seen that the holding properties of the dam have much improved. In 1884 with a mean maximum temperature of 78°·8, the loss of water for the whole year was 89·6 inches, whilst in 1885 with a mean temperature of 80°·1, or a daily increase of 1°·3 the loss of water was 76·1 inches, or less by 13½ inches than that of the previous year. This is satisfactory, as it shows that, so far, percolation has decreased.

There is a rain gauge fixed a few hnndred yards from the embankment, but it is necessary for estimating the amount of water that might be expected from a certain fall, to have stations fixed at several points of the drainage area of the dam. Such other stations have been established recently. The rains being very partial, a storm may occur only a few miles away and bring a considerable quantity of water to the dam, while the gauge at the bank registers nothing. Judging from the observations that have already been taken here, one half-inch of rain practically gives no increase to the dam, unless it immediately follows a previous fall. (See annexed report on the rainfall, 18th May 1885.)

In conclusion may be given a short description of the distributing channel or furrow. Mr. Alston's tender being accepted, operations for this part of the work were commenced on the 1st of January 1885, and finished within the specified time of five months.

The dimensions of this channel are 3-feet wide at the bottom, 11-feet wide at the maximum water level and 2-feet deep, giving a sectional water area of 14-square feet.

Banks were made on either side 2-feet wide on the top with a mininimum height of 3-feet above the bottom of the furrow.

The slopes were 2 to 1 below, and 1½ to 1 above the highest water level. Wooden forms were constructed to the finished section of the channel as a guide to the workmen.

The gradients of the channel are at the rate of 3-feet per mile for the first half mile, 2-feet per mile for the next two miles, the remaining length being at the rate of 1 foot 9 inches per mile.

The bottom and sides for the first quarter of a mile are pitched with stones, but the remaining part has no such protection, and up to the present time has stood well, the water flowing regularly, without scour. Openings, protected by pitching, have been left in the banks at suitable places, to carry off flood water ; these will probably require some repairs after storms.

The branch main road to Kenhardt, *via* Van Wyk's Vley, is carried across the channel by means of a bridge, with stone abutments and wooden beams, the main road crosses by means of a drift pitched with large stones, and well gravelled.

The length of the channel is a little over four-and-a-half miles, the surveyed plots beginning at a distance of about two miles from the reservoir. The land along the first portion of the furrow is at present reserved by Government, for tree planting &c., it being too narrow to be given out as corn lands.

A variety of trees and slips were planted here last July and August and most of them are thriving. Some poplar slips have now attained (in nine months) a height of more than 8-feet, showing that they at least grow exceedingly well. Mr. Alston has charge of the tree planting here, and will test what trees are most suitable to this part of the country, and the result, being a matter of great public importance, will be looked forward to with interest both by those who are lovers of nature and by those who look to the financial side of the question.